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naval stores

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Naval Stores Industries--
Research Needs

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NAVAL STORES PRODUCTS, primarily turpentine and rosin, have been an integral part of the economy of the Southeast since the first colonists landed in America. For 300 years they were used primarily in building and maintaining sailing ships, hence the name naval stores. With the advent of metal-hulled craft, this use diminished, but for a time developing industry found many other uses for gum naval stores products. In recent years, however, competitors have been making inroads on these markets; now the entire naval stores field is faced with the critical problem of an oversupply of high-priced products and rapidly decreasing outlets for them.

There are two competing segments of the naval stores field: the gum naval stores industry, which utilizes the resinous product of the living pine tree; and the wood naval stores industry, which uses stumps and other pine wood from cut-over land after turpentining, lumbering and pulping operations are finished.

Georgia is the heart of the world's largest naval stores-producing region, and the turpentine still, as seen on the cover, is a familiar sight in south Georgia. Because of the importance of naval stores to the state, the Georgia Tech Engineering Experiment Station is conducting continuing studies and has published three bulletins on the subject.[1, 2, 3] In the year ended March 31, 1954, the state produced 137,600 barrels (50 gallons each) of turpentine and 411,768 drums (517 pounds each) of rosin, with a net value to the producers of $21,500,000. Georgia's share was 77.4 per

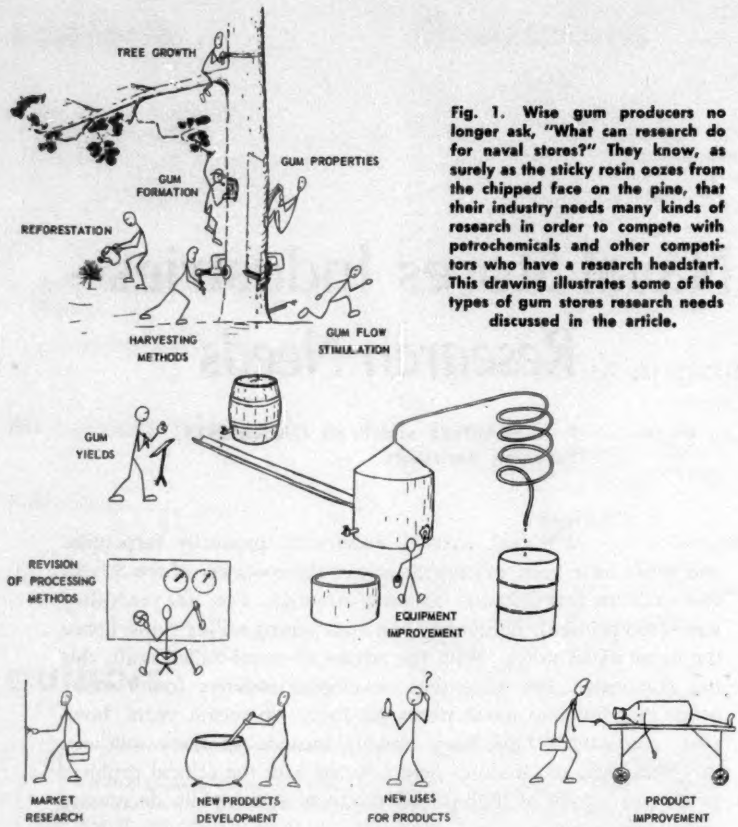

Fig. 1. Wise gum producers no longer ask, "What can research do for naval stores?" They know, as surely as the sticky rosin oozes from the chipped face on the pine, that their industry needs many kinds of research in order to compete with petrochemicals and other competitors who have a research headstart. This drawing illustrates some of the types of gum stores research needs discussed in the article.

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cover

Acres and acres of rosin drums surround the modern steam distillation plant at Valdosta shown on the cover. The Olustee System for Gum Cleaning and Distillation—so-called because it was developed by the U. S. Department of Agriculture's Naval Stores Research Section, Olustee, Fla., near Lake City—rapidly is replacing the old-fashioned, obsolete turpentine fire still.

Another symbol of progress in the naval stores field is the metal drum, prominent in the cover photo. First used in the early 1940's, it virtually has replaced the old wooden barrel. The gum purchaser formerly paid on the gross weight, so the producer customarily used heavy, green staves in making the barrel. Today, he pays on the net weight, so the heavy container is no longer an advantage—but, rather, a disadvantage—to all handlers.

cent of the total United States production, which, in turn, was approximately 60 per cent of the total world production. Yet, in the past five years, gum naval stores production has declined 44 per cent, suffering primarily from the competition of petrochemicals, but also at the hands of the wood naval stores industry, which now produces twice as much turpentine and two and one-half times as much rosin as does the gum industry. The decline in the gum naval stores industry means a loss of millions of dollars annually to the people of Georgia and the rest of the Southeast.

Research is doing much, but could do more, to bolster the gum naval stores field. Some of the research needs are shown graphically in Fig. 1.

Two Competing Industries

Prior to 1900 virgin forests were plentiful, and naval stores boomed; when one area was worked out, producers moved on to new forests—from Virginia and North Carolina through South Carolina, Georgia, Alabama, and on to Mississippi and Louisiana. Since reaching a peak output in 1908, gum naval stores production has declined, partly because of dwindling forest resources, partly because of competition from the developing petrochemical and wood naval stores fields. Selective cutting and other woods practices reached their lowest ebb during the depression of the early 1930's, when tree resources were so depleted that very small trees were turpentined—trees so small, in fact, that one-third of them were too inadequate for later utilization as saw logs.

The wood naval stores industry uses raw material of two general classes, stump wood and top wood. The former is richer in extractable products, but the latter also contains considerable amounts of rosin and oils. The straight portion of the tree (from the stump to the first branches) is very poor in rosin and oils and is generally culled. In woods operations the top wood, if too large in diameter for processing into turpentine and rosin, is simply cut into four-foot lengths and split. Stumps are generally blown out with dynamite or pulled out by a bulldozer with a special stump-pulling blade. The pieces of wood are then hauled to a railroad and shipped in box cars, gondola cars or rack cars directly to the plant.

Wood should age for several years so that the nonresinous parts will rot away, leaving only that part which is valuable for processing into naval stores products; top wood requires at least five years of aging and stump wood two or three years longer. "Green" wood occasionally has been tried, but yields of rosin and oils are low, and the difficulty experienced in milling is so great that its use is impractical.

The gum naval stores industry is rapidly losing its markets to competitive, cheaper products from other industries, petrochemicals as well as wood naval stores. The wood naval stores industry also is in trouble, because it is faced with declining raw material supplies, the natural culmination of its operations, and there is little hope of future sup-

Fig. 2. Forester Francois Mergen of the U. S. Forest Service's Southeastern Forest Eperiment Station branch at Lake City, Fla., applies pollen from a superior tree to a slash pine flower, which has been encased in a cellophane bag to prevent its indiscriminate pollination. This slash pine is in a plantation raised from seedlings from superior trees tested in a forest stand.

Fig. 3. Naval stores research already has produced improved methods and equipment for gum collection. Two new techniques shown in use on this tree are bark chipping and acid-spray stimulation. Together, they saved the gum industry more than $1,000,000 in 1952 when applied to approximately 40 per cent of the producing trees. Authorities say that these methods, if used throughout the industry, would save several million dollars and 1,000,000 man-days of labor per year. The new equipment shown includes a curved gutter and new-type apron and cup, all made of rustproof metal. (They are affixed with double-headed nails, so that the collection assembly can be removed easily after the tree is worked out, and the entire tree then can be utilized for lumber.)

plies of the same type in this part of the country. It started as a waste-utilization industry, using the residue of virgin forests left after lumbering and turpentining operations; this residue is now being exhausted, and the residue from second-growth forests is not suitable as a wood naval stores source. This is the major problem of the wood naval stores industry. The danger to the wood naval stores field is mostly an anticipated one, however, and temporarily it is flourishing because it is based not only on the sale of rosin and turpentine alone, but also upon the sale of many specialty products prepared from them. Consequently, fluctuations in the demand for any one product do not, to any marked extent, affect the over-all position of the industry.

The gum naval stores industry, however, built upon the sale of turpentine and rosin alone, is extremely sensitive to fluctuations in the demand for these products. Since the selling prices of rosin and turpentine have lower limits controlled by the high cost of collecting oleoresin, this is a critical problem for gum naval stores producers. The structure of the industry contributes greatly to the difficulties entailed in solving this problem. While the wood naval stores industry mainly is composed of large producers who can afford to investigate and solve the problems which develop, the gum industry is comprised of numbers of small producers who singly do not have the money to finance the investigation of their problems and who, to a large extent, are not fully cognizant of the advances which planned research can bring. The gum industry today is in an excellent raw material supply position. Reforestation has restored the raw material supply, and with proper management the forests of the South can continue to yield immense quantities of oleoresin for an indefinite time.

Opposite Positions

The two main phases of the naval stores field then are in diametrically opposite positions, to oversimplify somewhat. The wood industry has a large variety of products, which makes it economically stable, but it faces the problem of rapidly disappearing raw materials. The gum industry, on the other hand, has potentially unlimited supplies of raw materials but is economically unstable because of its paucity of products. Research is needed in both branches of the industry, although for different reasons and along somewhat different lines.

There is a third phase of naval stores which shows great promise—the sulfate naval stores industry, utilizing the by-products of kraft pulp and paper making. Sulfate turpentine and tall oil only recently have reached a position of economic importance. The potential value of sulfate naval stores products seems to lie primarily in the utilization of tall oil, which is a rich source of both resin acids and fatty acids. One problem yet to be overcome is that the supply is dependent on the demand for kraft paper products, as well as the relative cost of competing naval stores products. Some wood naval stores producers are now considering tall oil as a possible raw material for their operations; this and other phases of utilization and processing could bear considerable investigation.

Research Opportunities

Many of the problems which the gum naval stores field faces can be solved by properly planned research. The types of research needed fall into four main categories:

1. Procurement of raw materials.
2. Improvement of processing methods.
3. Improvement of existing products.
4. Development of new products.

These categories could be subdivided into long-range investigations and related, but separate short-range projects. The long-range investigations would include research of a fundamental or continuing nature, studies from which no concrete commercial development could be expected immediately but which would increase our fundamental knowledge of naval stores raw materials, processes and products, and which would point the way toward future commercial operations. Short-range projects would be specifically concerned with subjects of immediate commercial importance.

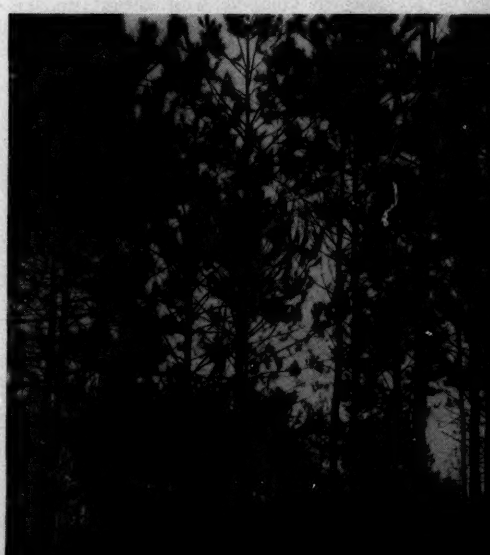
In the long-range study of raw materials and their procurement, there are several general avenues of research which should be followed. For the gum industry, studies should be made on these subjects:

1. Factors affecting tree growth and resin yields, with emphasis on the selection and development of fast-growing, high-yielding pines. The forester shown in Fig. 2 is utilizing one of the latest techniques in this category.

2. Improved methods of collecting and harvesting oleoresin, with emphasis on the development of new and improved equipment, some of which is shown in Fig. 3.

3. Reforestation of worked-out areas, with emphasis on the planting of improved species of pine so as to obtain the greatest possible integration between naval stores practice, lumbering and grazing. Examples of these better trees

Fig. 4. Research has produced superior trees. By cupping tests conducted over a period of time, investigators have found that in the forest certain trees, like several of the slash pines in the center of this photo, yield a greater than average amount of gum. Seed, under controlled pollination (see Fig. 2), are collected from these superior trees and planted in nursery beds. Seedlings thus obtained are transplanted, and the result is a strain of high-yielding trees. These methods, combined with fire protection and other good forestry practices, are adding greatly to the dollar value of our forest resources.



are those shown in Fig. 4.

4. Oleoresin, its composition, analysis, properties and yields, with emphasis on the mechanism of its formation and the factors affecting its composition, formation and properties.

Although much research has been carried out with the various portions of oleoresins, and the major constituents have been fairly well characterized, comparatively little information is available concerning the numerous minor components. Many of the early investigations on the constituents of oleoresins have yielded doubtful results because of the nature and history of the primary compounds present.

None of the four phases of study suggested for the gum naval stores field can stand alone. They are interdependent and should be pursued with constant liaison between the various phases of the over-all investigation. Neither can research along these lines ever be pursued to completion: the industry always can develop better trees, find better methods of harvesting, and learn more about oleoresin. However, as studies produce results, the cost of pine gum as delivered to the still will go down, while the profit to the farmer will be maintained, and the products of the gum naval stores industry will be better able to compete with cheap products from other industries.

For Immediate Attention

As fairly short-range projects for immediate attention those interested in the field might consider the following:

1. Effects of chemical stimulation on tree growth and oleoresin yield.
2. Effects of chemical stimulation on the composition and properties of oleoresin.
3. Development of better chemical stimulants (especially those of a non-corrosive nature).
4. Methods of qualitative and quantitative analysis of oleoresin.
5. Development of disposable cups for collecting oleoresin.

There are, of course, many other such topics that could be investigated. These are mentioned as problems of particular interest now and which offer promise of at least partial solution in the near future. Some of them are currently being investigated.

The main raw materials problem of concern to wood naval stores producers at this time is to find a raw material source to take the place of the virgin stump wood that is rapidly being exhausted. While the problem is only anticipated for several years hence, it is recommended that wood naval stores producers consider investigations along these lines:

1. Use of oleoresin as a raw material. This would be dependent on the future cost of oleoresin.
2. Use of tall oil as a raw material.
3. Use of second-growth stump wood as a raw material. This would require investigations of the resin content of stump wood and the development of uses for the by-product cellulosic residue.
4. Development of pine trees with a high residual resin content.
5. Use of stump wood from other species of pine from various sections of the United States.

Other Research

There are numerous short-range projects which would be of great value. Some of these are:

1. Studies on the resinous content of second-growth pine wood.
2. Studies on the types of resins and oils obtained from the stump wood of species of pine other than those of the Southeast.
3. Studies on the composition and properties of tall oil and on the factors responsible for variations in them.

Much research done by the large wood naval stores producers is not released for publication, and it is quite likely that parts of this work are now being done by some of the companies concerned.

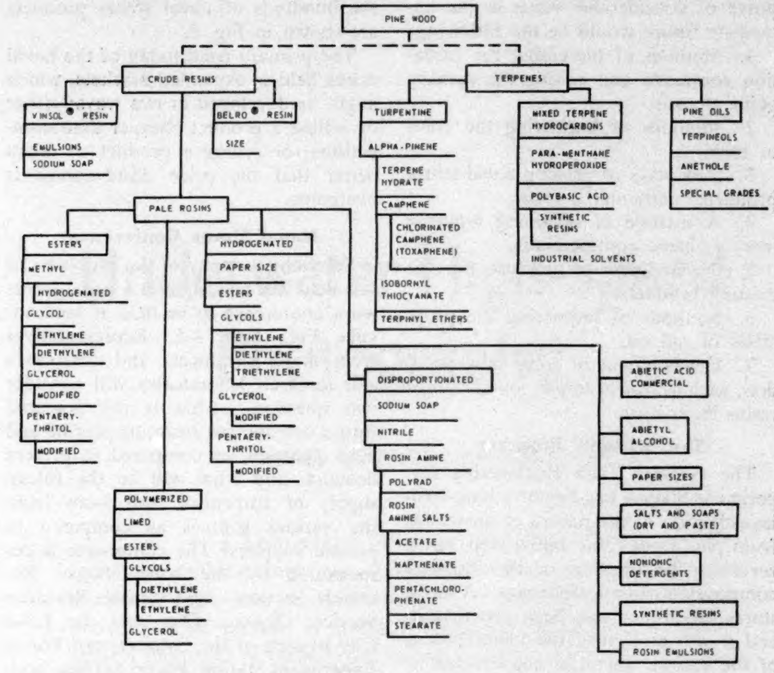


Fig. 5. Some of the hundreds of products derived from pine wood are charted here.

Research on processing methods can be divided into two parts:

1. Improvement of existing methods.
2. Development of new methods, particularly with regard to oleoresin.

Methods of separating the constituents of oleoresin more fully than is accomplished by present methods should be investigated. This may require only the improvement of existing methods, or it may require entirely new techniques. The constant study of ways of cutting costs and improving the quality of products obtained in present processing methods presents a continuing challenge to the industry to stay abreast of over-all technological advancement.

Studies on the improvement of existing products and on the development of new products are imperative if the entire naval stores field is to become stable and prosperous. Fundamental long-range studies of the composition, reactions, and physical and chemical properties of rosin, turpentine, pine oil, and the compounds derived from them should be carried out on a continuing basis. Such subjects easily could be assigned as problems for graduate research at the universities of the Southeast. Such research would, of course, be made up of numerous fairly small projects which would require from one to three years to complete. The financial rewards of such research would not be immediately apparent, but this work would serve as the basis for the future commercial development of many products.

Short-range programs which would

prove of considerable value in the immediate future would be the following:

1. Methods of increasing the oxidation resistance and raising the melting point of rosin.

2. Methods of improving the color of rosin.

3. New ways of grading naval stores products, particularly rosin.

4. A method of obtaining β-pinene from α-pinene commercially.

5. Development of new uses for the existing products.

6. Methods of improving the properties of tall oil.

7. Development of some new products, such as, for example, ion-exchange resins from rosin.

The Station's Program

The Georgia Tech Engineering Experiment Station has begun a long-term investigation of the nature of oleoresins from pine trees. The initial step was a review of the literature on the chemical composition of pine oleoresins. A naval stores laboratory has been established, and it will undertake the identification of the various chemical constituents of the gums, the determination of methods for quantitative analysis and separation of these components, and an investigation of the changes which occur in oleoresin constituents from the time they are produced in the tree through the usual processing procedures to the final products. It is hoped that the resulting increased fundamental knowledge will be beneficial in developing new and better applications for pine gum and consequently will stimulate a greater demand for this product of the gum naval stores industry of Georgia.

The many millions of acres of pine forest growing in the Southeast constitute the region's greatest natural resource. These forests provide an enormous supply of raw materials which ultimately are used by many different industries—lumbering, paper-making, printing, painting, dyeing, mining, textile and pharmaceutical, to name a few. The origins and derivatives of a few of the hundreds of naval stores products are shown in Fig. 5.

The primary need today of the naval stores field is expanded markets, which might be developed in two ways: either by selling a product cheaper than competitors, or selling a product so much better that the price disadvantage is overcome.

Naval Stores Conference

Solutions to many of the problems of this field will be sought at a naval stores work conference to be held at Jacksonville, Fla., Nov. 4-5. Representatives from major producers and consumers and research laboratories will consider two questions: what is the potential future demand for rosin, turpentine and pine oleoresin, as compared to present demand; and what will be the future supply of turpentine and rosin from the various sources as compared to present supplies? The conference is cosponsored by the Naval Stores Research Section, Agricultural Research Service, Olustee, Fla., and the Lake City Branch of the Southeastern Forest Experiment Station, Forest Service, both of the U. S. Department of Agriculture. The Georgia Tech Engineering Experiment Station will be represented by Dr. Frederick Bellinger, Head, Chemical Sciences Division, and Dr. Nathan Sugarman, Research Professor.

The problems of the naval stores field are too great to be solved by one organization alone—or at one single conference—but fostering integrated research by government and private groups is one of the surest ways by which the naval stores industries once again can provide a stable source of income for the people of the Southeast.

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Underwater High-Speed Photography

MARSHALL COOKSEY, Research Assistant

HIGH-SPEED PHOTOGRAPHY means either of two techniques, taking single exposures of extremely short duration or a series of exposures in rapid sequence. If one accepts the Chinese proverb "One picture is worth a thousand words," then surely several thousand pictures taken in one second must be of inestimable value; such, indeed, is the case, for high-speed photography has become indispensable in modern engineering research.[3]

Many of the uses of high-speed photography are routine and well known, such as time and motion analyses for industrial engineering. A unique and little known, but highly important, use of high-speed photography is for recording underwater phenomena, such as potent explosions.

High-speed photography is the antithesis of time-lapse photography, wherein events of long duration are photographed at wide intervals and viewed at a relatively rapid rate of projection, thus compressing the time scale within the limits of convenient human observation.

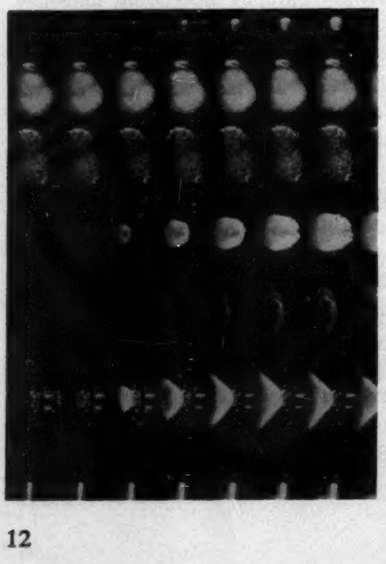
In many instances it is possible and desirable to study individual variables of rapidly occurring phenomena separately, and there are several techniques available, probably the most common being oscillography. These techniques generally require a separate transducer-indicator setup for each variable to be studied; the instrumentation and subsequent presentation and correlation of the data may become exceedingly elaborate. In many instances a series of photographs offers a simple, adequate method for

simultaneous study of the component variables of rapidly occurring phenomena, as shown in a random selection in Fig. 1.

The speed of the events being studied may vary from 1 meter per second to 10^8 meters per second, but as velocities increase above 3 meters per second, details become exceedingly difficult to discriminate. Many types of cameras have been developed to record events at various portions of this velocity range. Normal cinema cameras are available with repetition rates up to 128 frames per second. Special cameras for high-speed photography have been constructed with repetition rates up to 10^7 frames per second, with individual frame exposures as short as 0.01 microsecond.[1]

Cameras for high-speed photography are generally of three types, determined by the method of film movement. Intermittent-motion cameras, in which the film is advanced one frame at a time and held motionless during the exposure period can go no faster than approximately 250 frames per second. At a faster pace, the film is not physically strong enough to resist the terrific forces encountered in rapidly accelerating and decelerating. A new, thinner super-strength polyester film base soon to be marketed should greatly extend the capacity and speed range of moving film high-speed cameras.

Fig. 1. Short sections cut from various films taken at Georgia Tech of underwater phenomena.



Continuous motion cameras, through which the film moves continuously, have image movement compensating devices, such as rotating prisms or mirrors, between the lens and the film. These devices synchronize the movement of the projected image with the film movement. Cameras of this type employing 100 foot rolls of 16 mm or double 8 mm film permit a film speed to 250 feet per second, which is equivalent to 10,000 frames per second on the 16 mm and 20,000 frames per second on the double 8 mm films. This film speed results in a time magnification of approximately 675 to 1 when the 16 mm film is projected at 16 frames per second.

Drum-type cameras for frame rates of 20,000 frames per second and over employ a rotating drum holding a relatively short piece of film and use various types of rotating mirrors, prisms and secondary lens systems for image movement compensation. These cameras are capable of very high frame rates but yield a relatively small number of frames in a sequence of exposures. They are mostly custom-built machines and may weigh several tons and require many horsepower for driving the drum.

Three Cameras

Georgia Tech has three cameras for high-speed cinema photography. A professional 16 mm with a precision intermittent film-movement provides pictures of extremely high quality at frame rates up to 128 frames per second with independently variable frame exposure time. This instrument is quite versatile and for high speed work is generally preferred to other cameras, providing the

event velocity is not too great.

A 35 mm continuous strip-film camera with a frame rate of 500 to 1,500 frames per second also is available. This is a shutterless, continuous-film motion camera in which framing is accomplished by the commutator firing of gaseous discharge tubes in synchronization with film movement. The duration of the flash is sufficiently short to provide a sharp image, even on rapidly moving film. Obviously this camera is not suitable for photographing light-generating phenomena or for any subject matter where the ambient light level is high. The large film size and short individual frame-exposure time of approximately 30 microseconds make this camera particularly suitable for pictures of very high-speed events where good definition is important.

10,000 Frames

The third and most often used camera available at Georgia Tech for high-speed photography is a 16 mm continuous-film motion camera utilizing a rotating four-sided prism for image movement compensation and providing a maximum speed of 10,000 frames per second. The simplicity of operation of this camera, together with its reliability and the high quality results obtained, make it particularly suitable for much of the engineering research photography done here. It is compact, ruggedly constructed, and otherwise well suited for use where it is necessary to submerge the camera for underwater photography.

Since a fast film specially spooled for high-speed photography recently was placed on the market, the Engineering Experiment Station has used it almost exclusively. To save time on test runs, the film can be negative-processed in Steinman-type equipment which is normally used for developing oscillographic films. The test film has two disadvantages, a 50 per cent loss of film speed and a negative image for viewing. Those disadvantages are eliminated when the film is processed, as it normally is, by one of the two local commercial firms equipped for reversal processing.

Two Methods

Two methods are used here in making high-speed movies of underwater phenomena. In one, the camera, enclosed in a special waterproof box, is submerged with the medium to be photographed. In the other, only the subject mechanism is submerged, in a relatively smaller tank, and the photographs are taken through windows—made, incidentally, of bulletproof-type glass—in the tank walls.

There are five tanks available at the Engineering Experiment Station for underwater photography:

1. A round tank, 30 feet in diameter and 30 feet deep, and containing about 160,000 gallons of water, is shown in Fig. 2.
2. A rectangular tank, 10 x 4 and 4 feet deep.
3. A rectangular tank 6 x 4, also 4 feet deep.
4. A round tank, 5 feet in diameter by 4 feet deep.
5. A round tank, 4 x 4.

The four smallest tanks are located in individual concrete barricades adjacent to well protected instrument buildings. Each of the tanks has large supply and drainage pipes and convenient, high-capacity electrical outlets for AC and DC current at various voltages. Compressed air at pressures up to 3,000 pounds per square inch also is available in large volume at each tank.

Much of the subject matter photographed underwater involves explosions, further complicating an already difficult situation. The equipment constructed for submerging the camera must be unusually rugged, in addition to being completely waterproof; at the same time, its interior must be readily accessible, as the camera must be reloaded

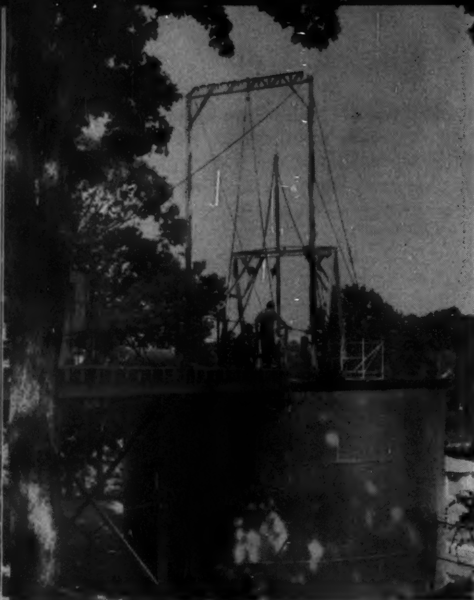


Fig. 2. The largest of the five tanks available at Georgia Tech for underwater high-speed photography is 30 feet in diameter and 30 feet deep (half of it underground) and contains approximately 160,000 gallons of water.

after each scene. Provisions also must be made for accurately aligning the camera and subject material so that focusing and framing can be accomplished, and this alignment must be maintained in the vicinity of explosions of considerable force. Since it is not economically feasible to drain the large tank after each test, the entire apparatus for submerging the camera was designed and constructed to facilitate easy lowering-into and withdrawing-from the tank. Fig. 3 shows the complete mechanism, which has proved quite satisfactory. A large hand electric drill was adapted to drive the winch; it raises or lowers the column about 20 feet in one minute. The camera is attached to a special mounting plate which fits between dovetail brackets in the water-tight box. To protect the camera against shock, a ⅜-inch sheet of foam rubber is sandwiched between the camera mounting plate and the box.

Compensation for differences in refractive indices of air and water must be made where the camera is focused in one medium and the exposure takes place in another. Thus, when the camera is submerged, focusing is accomplished by taking the camera-to-object distance and dividing by 1.34, the refractive index of water.[2] The calibrated focusing ring on the camera lens is set for the resulting distance. No compensation is necessary when pictures are taken through the bulletproof glass windows of the smaller tanks, since the conditions for visual focusing are the same as the conditions for exposure.

Protecting Equipment

To protect the camera when taking pictures through the windows of the small tanks, the camera is housed in a box constructed from sheet metal, as shown in the close-up, Fig. 4. Damage to the equipment from splashed water and chemicals thus is eliminated, and in one instance where the glass window broke, a complete loss of the equipment was prevented.

For some of the work done here, extreme close-up shots of moving parts are essential. Lens extension tubes for insertion between the lens and camera are available for the 16 mm continuous-film motion picture camera, but they are expensive and provide only for adjustment in relatively wide-spaced steps. A bellows attachment for a German-make camera was modified to provide a close-up focusing device which could be focused continuously rather than stepwise. Several makes of these bellows attachments were tried, but they were discarded because they did not allow the lens to be racked back far enough to focus at infinity. One extension tube was purchased and sawed in half to provide the bayonet mount. The mount can be removed and the second lens mount supplied with the bellows unit installed, which makes possible the use of the wide assortment of high speed

German-make lenses which are available commercially. No modification of the camera is necessary, and it can be restored to stock condition in a few seconds. This device has considerably extended the usefulness of our camera.

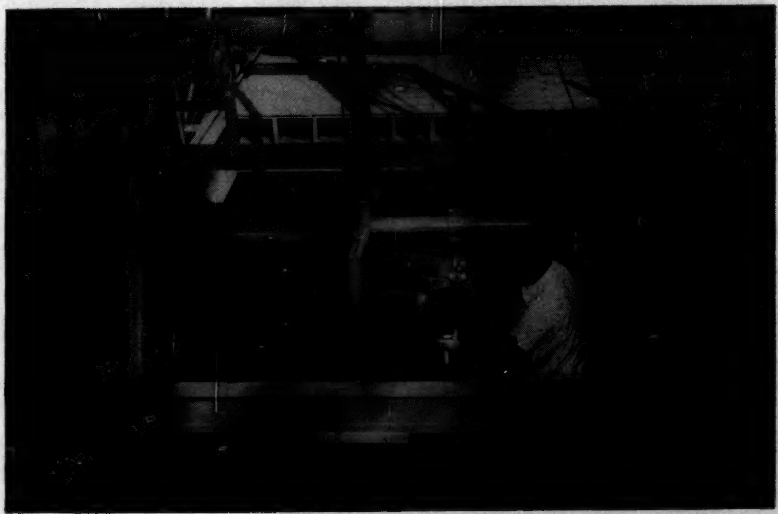
Problem of Light

Getting sufficient light on the photographic subject is often enough a difficult problem in air, but underwater it is the greatest problem encountered in high-speed photography. Small particles suspended in the water cause light scattering and absorption, thus greatly reducing the intensity normally expected. In addition, much of the scattered light may reach the lens by other than its normal optical path, thus reducing image definition and contrast. This condition greatly limits the maximum distances between the camera, the light source and the subject.

When the subject matter involves explosions, the lighting problem is further complicated by the necessity for physical ruggedness of the light source, which must be relatively close to the subject.

Various types of incandescent bulbs have been tried, with fair success, but the filaments of these bulbs are very sensitive to thermal and physical shock. RSP-2 and 750R reflector spot bulbs are used where the subject can be lighted from the surface or through glass windows in the tank. When it is necessary to submerge the light source, either a capillary high-pressure mercury arc or a series of photoflash bulbs can be used. It is difficult to stabilize the voltage sufficiently for the mercury arc; however, when a power supply with a special filtering section is used, no variation in light intensity is perceptible in the films. An AH-6 tube is operated at 800 to 1,200 volts DC, together with a reflector made of a piece of chrome plated brass bent to a parabolic shape.

Fig. 3. Marshall Cooksey, working in the largest tank, reloads the motion picture camera, which is housed in a watertight chamber. Left, center, just under the inverted V, is the bracket framework to which the explosive subject is mounted; the wires lead up to the mercury arc light source, at the approximate center of the picture; the camera lens aperture is on the left side of the chamber housing the camera. Subject, light source and camera can be withdrawn and resubmerged in a few minutes.



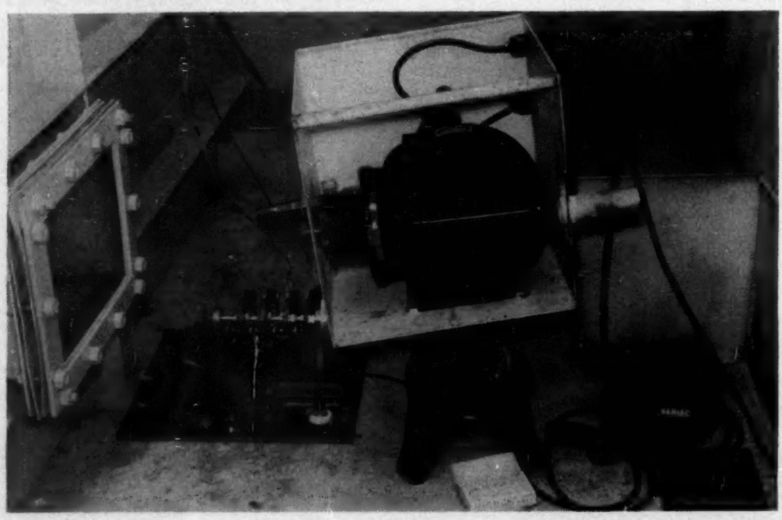
This unit emits the equivalent of approximately 4,000 watts of tungsten illumination. It can be located within two or three feet of explosions of the magnitude normally encountered in tank tests here. Extreme caution must be exercised in handling this apparatus due to the lethal potential involved. The quartz mercury arc tube is enclosed in a larger glass tube, through which cooling water is circulated, even when the tube is submerged. These tubes give excellent service if the polarity of the leads is switched occasionally. This light source aids visual observation of the phenomena under study, over and above being essential for taking photographs.

In instances where considerably more light output is required for an event duration of one second or less, focal plane type flash-bulbs are fired in sequence. Long-peak photoflash bulbs, which have an essentially uniform light output for 50 milliseconds, are usually used. These bulbs, when fired by a commutator at 50 millesecond intervals, have an almost flat-light output for any time interval required, so long as sufficient bulbs are used, as shown in Fig. 5 (a). Ten bulbs are usually used, providing 0.5 seconds of illumination, which is ample time for most events photographed under these conditions.

The bulbs are soldered to a copper ring providing a common ground connection and are fired by individual leads from the commutator. The arrangement is shown in Fig. 5 (b). This system is simple but has the disadvantage of lighting the subject from a series of different angles. This difficulty could be corrected by mounting the bulbs on the periphery of a wheel and by mounting the firing commutator coaxially on the wheel shaft, thus firing each bulb as it reaches a certain position.

Photoflash bulbs will withstand far greater physical shock than incandescent bulbs, since they have no delicate heated filament. Tests were made by lowering the bulbs 20 feet down in the large tank at three-foot and six-foot intervals from various size charges. A

Fig. 4. To protect the camera when taking pictures through the windows of the small tanks, the camera is housed in a box constructed from sheet metal. This assembly is not submerged.



maximum charge of 90 grams of black powder did not damage these bulbs, even at three feet.

Research Applications

The Engineering Experiment Station's bio-engineering laboratory has used high-speed motion pictures to study one mechanism by which aerosol particles may be removed from the air. A stream of air at sonic velocity was impacted on water. The aerosol particles, having more inertia than air, passed into the water. Motion pictures taken at 4,000 frames per second enabled the investigators to locate the distance from the tip of the nozzle at which impaction occurred and to observe other phenomena.

Much of the subject matter studied at Georgia Tech by means of high-speed photography is classified, precluding a more detailed discussion of those applications. The techniques and apparatus, however, are being applied increasingly to the economic solution of specialized problems of industry, particularly in the fields of textiles, chemicals, machinery and aerosols. The more experienced the Georgia Tech Engineering Experiment Station becomes in the delicate realm of underwater high-speed photography for defense purposes, the better qualified it is to offer all types of high-speed photographic service to science and industry of the South.

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1. CHESTERMAN, W. DERYCK: *The Photographic Study of Rapid Events.* Oxford at the Clarendon Press, 1951. Page 157.

2. COLE, ROBERT H.: *Underwater Explosions.* Princeton University Press, 1948. Page 213.

3. GARRETT, J. E.: "Photography—A Versatile Research Tool," THE RESEARCH ENGINEER, May 1949.

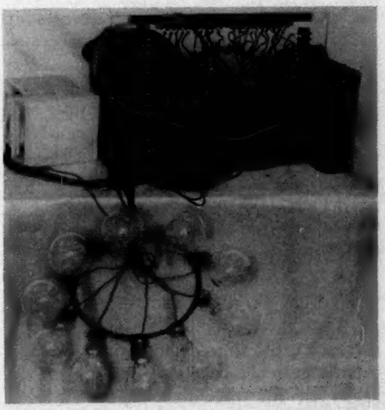
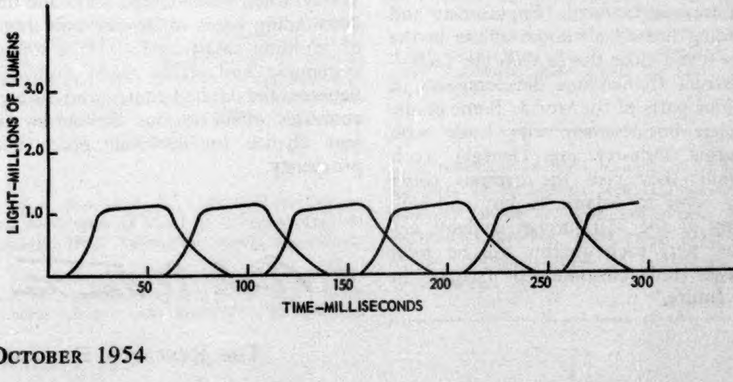


Fig. 5 (a) (below) The light output for a series of focal plane flashbulbs used in underwater high-speed photography. (b) (right) The experimental mechanism for firing such a series.



the president's page

Trade, not aid is a favorite subject of club speakers. Few Georgians who hear that platitude realize that Georgia today is not just talking about world trade, but actually is building world trade faster than any other southeastern state.

The Atlanta field office of the U. S. Department of Commerce recently released figures showing that the Georgia Customs district (Savannah, Brunswick and Atlanta) leads all other southeastern districts in rate of gain in dollar value of goods shipped to other countries. Exports from Georgia increased in cumulative value 195.5 per cent, from $12,500,000 for the first six months of 1953, to $36,900,000 for the same period this year. Imports increased 7.1 per cent, from $30,900,000 to $33,100,000. In the nation as a whole, at the same time, exports declined 5 per cent, and imports declined 7 per cent.

Georgia Tech has an important stake in Georgia's increasing world trade. Research at the Engineering Experiment Station develops and improves many of the products which Georgia exports, such as naval stores, textiles and farm equipment. Engineering and building firms with home offices in the state—and close ties to Georgia Tech—construct tremendous developments in various parts of the world. Some of the foreign businessmen who trade with Georgia industry are Georgia Tech alumni; they visit the campus when they come to Atlanta to buy and sell. Many of the 250 foreign students enrolled here each quarter will be good foreign trade customers of Georgia in the future.

Much of Georgia's recent threefold gain in world trade volume can be attributed to the Savannah State Docks owned and operated by the Georgia Ports Authority. [Pres. Van Leer was the first chairman of the authority.] This facility, dedicated only two years ago, already is a $15,000,000 installation.

World trade is important to Atlanta, no less than to Georgia's port cities. Recognizing this, the Atlanta Chamber of Commerce has had a World Trade Council for several years. The council conducts an active, comprehensive program, including tours of Atlanta area industry which are very popular with foreign students of Georgia Tech and other colleges. It also publishes a "World Trade Directory," listing some 450 Georgia firms, and the only statewide, free publication of its type in the United States. The council recently helped to found another organization, the Foreign Trade Association of Atlanta, a service group for firms engaged in world trade.

Georgians historically have shown a profound interest in international affairs. Our cultural and trade relationships with foreign peoples always have been cordial and mutually profitable. Today, when world cooperation and understanding seem to be our only hope of avoiding catastrophic war, a sound, systematic and stable trade exchange between the United States and foreign countries offers to our democracy its best chance for survival, peace and prosperity.

Blake R. Van Leer

publications

REPRINTS

Wrigley, W. B., A Note on Moving Poles in Nonlinear Oscillating Systems, 1953. Twenty-five cents. Reprint 77.

Since poles of the complex immittance of a linear system represent the decrements and frequencies of rotating phasors in the linear time domain, it is suggested that a non-linear system might be represented by moving poles whose instantaneous decrements and frequencies are associated with phasors rotating in the nonlinear or time-distorted phase space.

Rhodes, J. Elmer, Jr., Microscope Imagery as Carrier Communication, 1953. Twenty-five cents. Reprint 78.

An analogy is drawn in which the optical system in a microscope corresponds to a communication channel; the illumination, to a carrier; and the effect of the object on the illumination, to modulation of the carrier. It is hoped that new techniques in each field can be suggested by their analogs in the other. One such suggestion concerning a new method for obtaining phase contrast microscopy is presented. (The Georgia Tech Sigma Xi Prize research publication of 1953-54.)

Rhodes, J. Elmer, Jr., Radiation Pressure Against Perfect Reflectors, 1953. Twenty-five cents. Reprint 79.

A generalized concept of radiation pressure is here developed and then applied to several kinds of waves: Sound waves in various media, waves on strings and springs, and electromagnetic waves. Also, a simple demonstration of radiation pressure (for waves in a ripple tray) is described.

Belser, Richard B., New Methods for Decorative Application of Metal to Glass and Ceramic Surfaces, 1953. Twenty-five cents. Reprint 80.

Two techniques for the decorative application of a metal to glass, ceramic, and certain mineral surfaces are described. By the use of indium, applied in its molten condition, or of a number of other metals such as silver, copper, gold, and aluminum, frictionally applied with a pointed rotating tool or disc, decorative designs or script may be applied readily to the named surfaces. Several uses are suggested for laboratory and research workers, hobbyists, artists, shellcrafters, and ceramicists.

BULLETINS

Daugherty, P. M., The Constituents of Pine Oleoresins, A Review, 1954. 26 pages. Gratis. Bulletin 19.

This bulletin surveys the technical literature on the fundamental chemical compositions of the complex mixtures called oleoresins. It also anticipates the establishment of a basic research program on gum naval stores, which it states would be of great benefit to the economy of the South.

Wastler, T. A., Naval Stores Industries—Research Needs, 1954. 63 pages. Gratis. Bulletin 20.

This publication, a companion to technical bulletin 19, discusses the use of gum oleoresin and stumpwood as sources of chemical raw materials. It also outlines a broad research program for several segments of the naval stores field. After a comprehensive review of the evidence, it concludes that research could solve many of the problems of the naval stores industry of Georgia and the Southeast, as well as open up new fields for the use of naval stores products in the chemical and other industries. (See article by same title, this issue.)

To order any of these reprints, or to get a complete list of Georgia Tech Engineering Experiment Station technical publications, write Publications Services, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia.

NEWS

of the engineering experiment station,

georgia institute of technology, atlanta, ga.

RESEARCH ENGINEERS THOMAS A. ELLIOTT, ROBERT L. ALLEN, AND BEN W. CARMICHAEL have been issued United States Letters Patent No. 2,674,374 on their invention, the corrugated slot screen for cleaning peanuts. The patent has been assigned to the Georgia Tech Research Institute, and six of the devices are in use during the 1954 peanut season. Dr. Paul K. Calaway, Acting Director, congratulated the inventors. "The issuance of this patent is the latest in a long list of creditable achievements during the five years the Station has been active in peanut equipment research," he said. "It will mean real savings to Georgia's $60,000,000 peanut industry."

DR. JOSEPH M. DALLAVALLE, *Prof. of Ch.E. and Res. Assoc., has returned from a year in Italy, where he lectured at the University of Milan as a participant in the Fulbright Program.*

DR. ROBERT S. INGOLS, Res. Prof., at the request of the Attorney General of Georgia, investigated an extensive and alarming fish kill on the Altamaha River near Jesup, in south Georgia, in Sept. He reported his findings in confidence to the Attorney General.

GROUND WILL BE BROKEN soon for a new wing of the Station's Research Building, the third major addition since the main portion of the building was constructed in 1939. The new wing will house the Rich Electronic Computer Center, the first at any southern college. The initial cost will be $340,000. The Rich Foundation of Atlanta and the Georgia Tech Research Institute have made grants of $85,000 apiece, and the University System Building Authority has matched those sums with $170,000, specifically for construction of the wing.